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REPORT OF THE ENTOMOLOGIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 14, 1919.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ending June 30, 1919, following your directions as to arrangement.

L. O. HOWARD,
Entomologist and Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

CEREAL AND FORAGE CROP INSECT INVESTIGATIONS.

The work of this section, continued under the charge of Mr. W. R. Walton, has been of especial importance during the past fiscal year.

EUROPEAN CORN BORER.—In the last annual report of the bureau it was pointed out that this recently discovered insect, accidentally imported from Europe and thoroughly established in a limited region in eastern Massachusetts, threatened to become a pest of great importance throughout the corn-growing regions of the United States unless immediate measures were taken to stop its spread. Shortly after its discovery in 1917, it was shown to occupy apparently an area of about 100 square miles in the immediate vicinity of Boston. Later it was found in the Mohawk Valley of eastern New York, and careful scouting work showed that by the autumn of 1918 it had spread over an area of some 400 square miles. Scouting work in Massachusetts during the autumn of 1918 and the early spring of 1919 showed a distribution throughout 500 square miles of territory. A very vigorous campaign, looking toward extermination, was begun under State agricultural organizations; the New York Legislature appropriated $100.000, the most of this sum being spent in the spring of 1919, and it is believed that much good was accomplished. A cooperative campaign was started in Massachusetts by Federal and State authorities under a State appropriation of $50,000, and a considerable part of the infested area was treated in the effort to prevent the natural spread of the insect. A Federal appropriation was asked for, but the bill failed to pass Congress, and all of the work done in the spring of 1919 was carried on with funds provided by the States of New York and Massachusetts. The vulnerable point in the insect's life history is in its hibernation as a caterpillar in the stalks of corn and in the stems of other plants which it attacks, and there is a large list of these. Therefore the most effective work can be done only when the insect is in hibernation; and by the failure of

the Federal appropriation the opportunity for very effective work was lost. The result was that, with the appearance of the moths issuing from untreated or imperfectly treated areas in Massachusetts, there was a spread at the end of the fiscal year, so that at the date of the present writing the insect is known to occur over an area of 1,000 square miles, extending from the New Hampshire border on the north to the towns of Marshfield and Brockton on the south, and to the west into the towns of Lincoln and Wayland.

Much new and valuable information regarding the habits of the insect was gained during the year, and several publications were issued by Federal and State organizations, including a Farmers' Bulletin (No. 1046) from the United States Department of Agriculture, giving information as to the best means of destroying the insect in its winter quarters. Several more or less effective means of destroying infested plants were discovered, and it is now being arranged to put these into operation on a large scale immediately after the expiration of the growing season of 1919. Fifteen trained entomologists are now investigating the habits and methods of destroying this pest, and every possible effort will be made to prevent its further spread.

The Hessian fly.—The annual spring survey of Hessian fly conditions has recently been completed and indicates plainly that this well-known pest is rapidly increasing in abundance in many localities, and has been responsible for a considerable amount of fallen grain in the States east of the Appalachian Mountains, especially in the Shenandoah and Cumberland Valleys. Reports from the western half of the Mississippi Basin also indicate a distinct increase. Warnings have been issued through the news service of the department so that wheat growers may plant at the proper date in the fall of 1919 in order to avoid loss.

The northern army worm.—The true army worm appeared in numbers during late May, 1919, in northern Texas, and damage was done to growing grains soon afterwards through Oklahoma, Missouri, Iowa, Illinois, and western Ohio. The usual remedies were successfully applied in most of the infested territory. In eastern Indiana a serious local outbreak was successfully handled by the county farm advisers under advice from this bureau. In this case the poisoned bran bait was used with excellent effect.

The southern corn rootworm.—As a result of recent investigations, it has been found that in large portions of the States of Georgia, North Carolina, and South Carolina corn planted before March 31 or after May 10 is more or less immune from the attacks of the southern corn rootworm. The Coastal Plain, however, from southern Virginia to Florida differs, and no regulation of planting time seems seriously to affect the insect in this region.

The alfalfa weevil.—A successful method of spraying alfalfa to destroy the alfalfa weevil has been found, and its efficacy thoroughly demonstrated in Utah. It is possible to apply this method successfully at a cost not to exceed $1 per acre, and serious losses, even to the first crop of alfalfa, can be avoided. This first crop, under previous methods of control, was usually sacrificed. The large-scale use of this method during the early part of 1919 resulted so

advantageously that the method will undoubtedly be generally adopted. The alfalfa weevil is at present causing much concern in Colorado, and spraying work has been undertaken in cooperation with the officials of that State.

Grasshoppers.—Much valuable assistance in the form of personal advice has been given to State and county officials in the successful conduct of grasshopper extermination work throughout the States of North Dakota, South Dakota, Minnesota, Iowa, Montana, California, Kansas, Nebraska, Missouri, Oregon, and Washington during the summer of 1918 and spring of 1919. The loss of many hundred thousand dollars' worth of crops has been prevented as the result of these activities.

Other insects affecting cereal and forage crops.—Studies of the jointworms have been continued with excellent results. Control experiments with the alfalfa-seed Chalcis have been carried on in cooperation with the Arizona Commission of Agriculture and Horticulture in the Buckeye Valley of Arizona, resulting in an apparent decrease of 15 per cent in the infestation and a net profit of more than $43 per acre in the experimental plot.

Experimental control work on the coulee cricket conducted during the spring of 1918 was apparently successful, and the insect has made no destructive appearance during 1919.

Studies of the alfalfa caterpillar, the harvester ant, white grubs, billbugs, wireworms, and the European sawfly in wheat have been continued with favorable results. The last-named insect has been watched with especial care, because it seems capable of doing considerable damage to the winter wheat crop under conditions favorable to its multiplication.

STORED-PRODUCT INSECT INVESTIGATIONS.

Dr. E. A. Back has continued in immediate charge of this branch of the bureau's work.

Corn weevils.—During the past year a laboratory has been established at Orlando, Fla., for the purpose of studying the biology and methods of control of corn weevils. Enough has already been learned of the biology of these insects to form the basis for control work. At Athens, Ga., an office has been established in cooperation with the Georgia Agricultural Experiment Station, from which expert information regarding preserving corn from weevils has been disseminated among southern farmers.

Bean and pea weevils.—The great increase in weevil losses to California-grown beans and peas during the past few years has led to the establishment of a laboratory at Alhambra, Calif., at which the causes for weevil increase and the methods of control are being investigated. The work has received the hearty cooperation of the bean growers and warehousemen of the Pacific coast.

Flour beetles.—The biology of various species of flour beetles of the genus Tribolium that attack flour in all warehouses throughout the United States is being made the object of an especial investigation with headquarters at Dallas, Tex.

Fumigation as a control method for stored-product insects.—Experimental work to determine the usefulness of fumigation in lessening or preventing the enormous waste taking place through insect attack to stored goods in warehouses, though as yet extending over only a short period, has yielded practical results of great value.

Electricity as a control agent.—During the past year cooperative work has been carried on to determine the effectiveness of electricity as a control agent in the suppression of insects in cereals in package form. A commercial machine for sterilizing cartons of cereals after the latter have been sealed has been installed in a large cereal factory, with every promise of practical value. Should expectations be realized, the electrical treatment will result in great saving both to producers and consumers.

Cold storage as a control measure.—The value of cold-storage temperatures in preventing insect damage to warehoused products has already been proved. Cold storage is being depended upon by wholesale and retail dealers of certain classes of foods and other products as the only satisfactory method of protection from insects. Detailed data regarding the effect of low temperatures upon various insects attacking stored products are being secured.

Household pests.—Investigation of household pests other than the bedbug, flies, and mosquitoes, which was discontinued during the war, has been resumed. Several pests that are believed by the general public to be limited to houses, as clothes moths, cockroaches, and carpet beetles, have been found to be frequently very injurious to valuable materials stored in warehouses throughout the country.

Inspection and intelligence service.—The arrangements made during the war with the Quartermaster Department of the Army at the port of New York, whereby the bureau has undertaken to make frequent inspections of food and clothing supplies, proved so satisfactory that they have remained in force and are being extended to other food depots, not only of the Army but of the Navy. The purpose of this cooperation is to keep the Quartermaster Departments of the Army and Navy informed, through inspections made by bureau experts, not only of conditions of food supplies purchased and delivered at the warehouses, but also of their condition from time to time during the storage period. Such inspections detect and lead to the checking of insect ravages before the insects have had a chance to multiply and cause great loss.

The dissemination of information regarding the suppression of insects affecting stored food supplies and food products, which during the past two years has monopolized the efforts of this branch of the bureau work, is being continued, although the return to a peace basis is making it possible to open up the new lines of research indicated in preceding paragraphs.

DECIDUOUS FRUIT INSECT INVESTIGATIONS.

Investigations of the insects of this class have been carried out under the direction of Dr. A. L. Quaintance, as formerly.

APPLE INSECT INVESTIGATIONS.

Codling moth.—Detailed life history studies of this insect, under way for some years in different parts of the country, were begun

during the fiscal year in two new localities, and much additional knowledge, especially with reference to climatic conditions as affecting severity of damage, has been obtained. Numerous localities reported unusual injury to apples about harvest time, from recently hatched larvæ producing the so-called "sting," and there was considerable demand upon the office for local studies of the life history of the insect as well as investigations in orchards to perfect spraying schedules. The "sting" damage to apples in one State was estimated to have caused a loss of $2,000,000 and the sum total of injury done by this pest in different regions represents a very heavy tax on the apple growers.

In Colorado, where work is being done in cooperation with the State agricultural experiment station, the life history studies were completed and the work was confined to orchards. In the Grand Valley in this State codling moth losses have always been severe, and many orchardists have been unable to obtain satisfactory control, even by thorough spraying. Study indicates that this was due to lack of co-operation among orchardists thoroughly to spray over a large area. Consequently arrangements were made with a number of contiguous orchardists whereby they individually agreed to spray according to the department's recommendations, and thus try out on a large scale the effect of uniformity of spraying operations over hundreds of acres. This prevents the overflow of codling moths from poorly cared-for orchards into well treated orchards, and good results are expected.

Cooperative work in the Rogue River Valley of Oregon has been continued. The approximate dates when the larvæ of the different broods enter the fruit have been established, and a sound basis has been gained for a schedule of applications not only for apples but also for pears.

In the Ozark region in Arkansas similar work has been continued, and has been done cooperatively with the Bureau of Plant Industry on account of the importance of plant diseases in the orchards of that section. It seems probable that in that locality dusting can not be relied upon as a substitute for spraying. There are three full broods of the codling moth in this region and a partial fourth brood. There is a distinct interval between the appearance of the first and second brood larvæ, but from that date on they are continuously in the orchards. These life-history studies in this region have been practically completed, and a sound spraying schedule will probably be arranged by the close of the present season.

Work of this general character has also been carried on cooperatively in Delaware and in the State of Washington, and at the bureau's laboratory at Wallingford, Conn., the codling moth has also been studied. The insect in the latter region is much less troublesome than in the central, southern, and western regions, and it seems likely that a single thorough spraying at the time of the falling of the petals will prove sufficient to protect the fruit.

Apple-tree and other borers.—The work with the apple-tree and pear-tree borers has practically been completed, and publications will shortly be issued.

Apple plant-lice.—Intensive work has been done with these insects, especially with reference to the exact determination of alter-

nate food plants and the identity of certain confused forms. This has involved an enormous amount of work, and decisive results are about to be reached.

In addition to the apple insects mentioned above, a considerable number of other species which live in apple orchards have been studied, but most of these are of lesser economic importance in the general run of seasons. As it often happens, however, that one of these minor pests becomes for a season or more very injurious, it is necessary that the bureau should anticipate such outbreaks by securing thorough biological information.

GRAPE INSECTS.

The grape-berry moth.—Vineyards were selected in several widely separated sections of the northern Ohio grape belt to serve as object lessons for vineyardists and to give them personal instructions in spraying effectively. It has been shown that the grape-berry moth can be controlled by two applications of arsenate of lead in spray form, leaving the fruit practically free from residue at picking time. In certain cases a single application has been sufficient, but here there were no surrounding badly infested vineyards. This indicates that eventually a single spray in general will keep the pest in check.

The grape mealybug.—Full life-history studies of this insect have been finished. Fumigation with cyanid of soda and with sulphur fumes has been satisfactory in the dormant season at night, but sulphur is considered the better. January has been found to be the best time for this work. Spraying has proved less effective than fumigation. A campaign of education among grape growers has been begun to secure their cooperation in restricting the spread of the pest on picking boxes and in other ways.

The grape Phylloxera.—In collaboration with the Bureau of Soils of this department, a survey of Fresno County has been made to determine the influence of the physical nature of soils on the degree of infestation of vineyards by the Phylloxera. Interesting and valuable facts have been ascertained. Investigations have been made concerning the best methods of disinfecting grape propagating stock destined for shipment.

The grape sphinx moth.—An interesting instance of the value of entomological knowledge occurred when this insect appeared in numbers in Tulare County during the fiscal year, over some 700 acres of vineyards. The bureau's agent cooperated with the vineyardists, and, at an outlay of about $12,000 for labor, spraying materials, and machinery, the grape crop, valued at $180,000, was saved.

A number of other grape insects have been studied and new biological data ascertained.

NUT INSECTS.

Pecan insects.—Special attention has been given to the use of insecticides in pecan orchards in Georgia and Florida. Arsenicals are being tried in the form of dusts and sprays, and another season's work should show conclusively the comparative merits of these two methods. In Texas, the bureau has been especially interested in the native pecan groves along river bottoms and elsewhere. In these

native groves satisfactory control is very difficult and insect injury is quite severe; in fact, 90 per cent of the pecan crop here was lost during 1918. Three species of insects are principally involved.

Insects injurious to walnuts, butternuts, etc., in the Northern States.—This work, especially with the walnut curculio, the hickory curculio, and another species that attacks the leaf stems of hickory, and with other species as well, has been taken up by the bureau, with headquarters at French Creek, W. Va. A thorough investigation of insects attacking nuts other than pecan throughout the country will be carried on.

CRANBERRY INSECTS.

In the last annual report the beginning of the work on insects in cranberry bogs in the State of Washington was mentioned. This work, in cooperation with the Washington Agricultural Experiment Station, has been continued and important results have been reached. On bogs badly infested by the blackhead fireworm satisfactory results have been secured from three applications at intervals of from 17 to 21 days between May 1 and July 1 of nicotine sulphate containing 40 per cent nicotine used at the rate of 1 to 800, with the addition of fish-oil soap at the rate of 2 pounds to each 50 gallons, the spray being applied at the rate of 250 to 550 gallons per acre. Of the spray nozzles tested that known as the Bordeaux appears to be best suited. Growers have generally adopted this treatment and are getting good results. Detailed life-history studies of this insect are nearing completion, as are also studies of the cranberry root weevil. It has been shown of this latter species that it can be controlled by spraying the foliage during May and June with 2 pounds of arsenate of lead to 50 gallons of Bordeaux mixture.

A general survey of insect conditions is being made on cranberry bogs on the Pacific coast, and it is hoped that by the close of the season a report can be prepared on the principal cranberry insects of that territory.

PEACH INSECTS.

Tests of paradichlorobenzene as a treatment for the peach borer were continued through the growing season of 1918. Experiments with this gas have now been carried on during a period of three years in the peach districts of Maryland, Ohio, Arkansas, Virginia, West Virginia, and Georgia. In some cases blocks of trees have been treated two and three years in succession. It has been found that three-fourths of an ounce or 1 ounce of the chemical per tree applied in the fall after the moths have laid their eggs will result in the destruction of about 95 per cent of the larvæ. No injury has resulted from this dosage to trees 6 years old and over. Younger trees, on account of their thinner bark, have sometimes been injured.

Experiments as to the comparative merits of dusting and spraying in the control of the plum curculio and certain peach diseases have been continued in cooperation with the Bureau of Plant Industry at Fort Valley, Ga., Agricultural College, Miss., and Bentonville, Ark. The summer of 1919 has been an unusual one and control measures have been put to a severe test. The dusting method in a general way seems to compare favorably with spraying, even under the worst conditions.

THE JAPANESE BEETLE.

The introduction and establishment of this insect in the vicinity of Riverton, N. J., was mentioned for the first time in the last annual report. The work of eradication and control has been vigorously prosecuted in cooperation with the New Jersey State Department of Agriculture. The operations have been materially enlarged, but in spite of all that has been done the insect is increasing rapidly, spreading over new territory, and at the time of the present writing is perhaps 150 per cent more abundant than at the same time last year. Many experimental lines are being worked. Cyanid of soda in solution has been used to destroy the grubs in the ground, at the rate of 1 pound to 200 gallons of water and applied at the rate of 22,000 gallons per acre. While the beetles are flying, a wide barrier of poisoned foliage is maintained as completely as possible around the whole area of infestation. Where the beetles are most abundant they have been systematically collected in hand nets. An active collector can secure several quarts of the beetles in a day, and as each quart contains 4,000 individuals, this method is important. About 1,000,000 beetles have already been collected. Plowing the soil infested by the grubs and pupæ appears to destroy them. It will be necessary to do this kind of work very extensively in waste places and many areas not under cultivation. Weeds along the roadsides have been burned to destroy their food and render such places unattractive to the beetles, thus reducing the danger of their being carried by vehicles, pedestrians, and so on. In the same way, waste places along ditches and other spots which can not well be treated with cyanid are being cleared of weeds, and this work is being extended into the wide barrier of poisoned foliage surrounding the area of infestation. Close study is being made of the relative abundance of the insect in different parts of the area and on the methods of dissemination, and a quarantine is in force providing for the examination and certification of green sweet corn going out to market, since the beetles penetrate the tips of the ears and could thus be widely spread. A local citizens' committee has been established, which is of greatest assistance in the work of arranging cooperation of property holders with the agents of the bureau and the State. The work is now well organized, and we have a much better idea of the problem. It seems, from the rapid increase and spread of the insect during the summer of 1919, that the work must be greatly enlarged to be entirely successful.

INSECTICIDE INVESTIGATIONS.

At the various field laboratories tests have been made of many proprietary insecticides in comparison with homemade articles.

Work on the so-called "Derris," an insecticide made from plants of the genus of this name, has been completed. If this insecticide can be obtained in sufficient quantities it will prove an important addition to our list of substances that kill soft-bodied insects like plant-lice.

Studies of the various arsenical insecticides, like arsenate of lead, arsenate of lime, zinc arsenite, and so on, have been continued. Large-scale feeding experiments have been carried on with caterpillars and other insects. Experiments under different climatic conditions with these substances have also been continued. Additional expe-

rience confirms the conclusion reported last year that arsenate of lime may be used in all situations as a substitute for Paris green, and that it will also, for pomaceous fruits, prove a satisfactory substitute for arsenate of lead when used with lime or fungicides containing lime.

It has been shown that nicotine sulphate is an unsatisfactory substance to use against the eggs of the codling moth in the field. Nicotine is, however, coming rapidly into use as an insecticide in other ways, and the bureau has been trying to find a less expensive substitute. The results already obtained are promising. Basic studies in connection with this work have been made on the physiology of injurious insects, especially on their olfactory organs, and a number of publications have been issued on this subject.

NATURAL CONTROL.

Under this head, studies of insect-destroying fungi have been continued, especially a fungous disease of cutworms. An obscure disease of the so-called seventeen-year locust, or periodical Cicada, has also been studied.

Work with the ladybird known as *Hippodamia convergens*, in the Imperial Valley of California, has been continued in cooperation with the California State Horticultural Commission, especially in regard to certain needed changes in the method of handling the insects. This work will be continued.

An especial study has been begun of the natural enemies of the plant-lice which are injurious to walnuts in southern California.

INVESTIGATIONS OF INSECTS INJURIOUS TO VEGETABLE AND TRUCK CROPS.

Work upon this group of insects has been continued as heretofore under the direction of Dr. F. H. Chittenden. Under the necessity for stimulation of food production much of the research conducted on the less important subjects under this head was temporarily discontinued, and attention was especially directed to the important staple crops.

SWEET POTATO WEEVIL ERADICATION AND CONTROL.

Continuing the policy of the fiscal year 1918, under a $50,000 allotment for the eradication and control of this insect, intensive work was done. The definite boundaries of infestation were established in Florida, Georgia, Alabama, Mississippi, Louisiana, and Texas. More than 30,000 farms were inspected during planting and harvest (since at these times the presence of the weevil is most apparent), and the infested properties were listed and mapped. Large-scale experiments in control have been continued. In one large eradication project in Florida, selected for demonstration since it embodies most of the serious difficulties to be encountered, material progress has been made. All of the infested estates have been subjected to continuous supervision, contracts have been made with the growers for the destruction of all seed potatoes grown on infested land, and the scrupulous execution of these contracts has been rigidly enforced. More than 1,000,000 weevil-free sweet-potato draws have been distributed to growers by

cooperation with the Florida State Plant Board. This materially aids in the eradication of the weevil without interfering with the production of potatoes, since the contracts provide for clean culture and a fallow period of six weeks prior to planting, together with other repressive measures. It is believed that as the result of this work the end of the growing season will find this locality practically, if not completely, weevil free.

In Alabama, the infestation was found to be confined to a single well-defined locality in Baldwin County, and excellent cooperation has been secured with growers toward the application of all necessary repressive measures. It is believed that this isolated outbreak will be entirely cleaned up in another season.

In Mississippi the passage of a drastic crop-pest law materially aided in the eradication measures, the establishment of a quarantine rendering complete control of intercounty shipments possible. The comparatively light infestation in this State has been mapped, and a material reduction of the area infested has been secured.

In Louisiana survey work has been continued, and growers have been visited and urged to apply methods devised by the bureau. Reinspection recently indicates that gratifying results have been reached in the majority of cases. A careful study has been made in this State as well as in Mississippi of the other food plants of the morning-glory group, especially the large-rooted perennial morning-glories, and a number of chemicals have been tested as weed killers, to be used against these wild food plants.

In Texas, 85 counties have been found infested with the weevil, which has been distributed apparently largely through commercial growers of slips shipping from the Gulf and south-central portions of the State. There is no law in Texas controlling the shipment of infested plant material, which is a serious drawback to the control of the weevil in that State. The fact that salable sweet potatoes can not be produced in some of the coast counties has helped the widespread distribution of the weevil, as draws grown from unsalable stock often prove more profitable than the growing of tubers. Life-history studies at Kingsville, Tex., showed at least six generations of the weevils annually, indicating an enormous rate of increase. Spraying experiments at this point have reduced infestation from 44.51 per cent to from 2.88 to 12.18 per cent.

INSECTS AFFECTING POTATO, TOMATO, AND ALLIED CROPS.

The potato aphis, an unexpected pest which made its appearance in 1917 and again in the early summer of 1918, was experimented with on into July, 1919. The use of nicotine sprays at increased strengths demonstrated practical control in Maryland, New Jersey, and Maine.

The spinach aphis, which has during recent years become troublesome as a potato pest, and which also affects cabbage, beets, lettuce, and other staple vegetable crops over a still wider range of territory, has been the subject of continued investigations along the Atlantic coast. A new station in the Aroostook region in Maine, a great potato center, has been established for the study of the Colorado potato beetle, the potato flea-beetle, and other potato pests. An investigation of the spread of the Colorado potato beetle on the Pacific

coast has been conducted. The infested localities have been mapped and a campaign has been begun to spread a knowledge of the importance of control measures.

Other potato insects have been studied in Wisconsin and Iowa.

INSECTS AFFECTING GROWING BEANS AND PEAS.

The bean ladybird has recurred in numbers in Colorado and New Mexico. Experiments have shown that it can be controlled with lead arsenate and zinc arsenite sprays.

The enormous plantings of beans in southern California, owing to war conditions, resulted in serious injury to the crop from the corn earworm, and investigations of this insect under these conditions have been made. The tremendous spread of this crop resulted in the great multiplication of the insect, and with the reduction of the bean acreage this season serious damage will very likely result from the abundance of the pest.

The pea moth, an imported pest already well established in Canada, has made its appearance in injurious numbers in Wisconsin, where it seems to be greatly increasing in number, necessitating additional investigations of its life history in order that a sound remedy may be established.

INSECTS INJURIOUS TO CABBAGE AND ALLIED PLANTS.

An investigation of the western cabbage flea-beetle, a pest of much importance in the Western States, has been completed, and the results are available for immediate publication.

The harlequin cabbage bug, after one of the periods of inactivity in the North which have several times been noted, is likely now to reinfest its northern range at any time, and an emergency bulletin on methods of control has been prepared.

An imported horse-radish pest, hitherto known as injurious only in Canada, has made its appearance in destructive numbers in Virginia, and is being studied. It will live on other crucifers, and if not controlled may become a pest of much importance.

SUGAR BEET INSECTS.

Work on the sugar beet leafhopper, which is the cause of the malady known as "curly-top," was terminated at Spreckles, Calif., and the station was removed to Riverside that the study of certain points in the life history of the insect and the relation of temperature and humidity to its development might be completed. A considerable percentage of parasitism has been observed during the year.

OTHER TRUCK CROP INSECTS.

Much good work was done with a number of other insects, including the onion thrips and the onion maggots, the melon aphis, several strawberry insects, and others. A notably good result was obtained in the case of the celery leaf-tier, since it was demonstrated that it could successfully be controlled by spraying with arsenate of lead at the rate of 1 pound to 50 gallons of water, the first spray to be made when the eggs are hatching and repeated every two weeks as long as the "worms" are to be found. This was accomplished at a cost, for labor and material, of $2.35 per acre.

INVESTIGATIONS OF INSECTS AFFECTING FOREST RESOURCES.

The work in forest entomology has been continued during the past year under the direction, as before, of Dr. A. D. Hopkins. The results accomplished by this section of the bureau deserve especial mention and justify the expenditure of a larger sum of money in this direction.

WESTERN FIELD WORK.

An especial investigation of the insect damage to crude spruce products for airplane stock in the States of Washington and Oregon showed that the greater part if not all of the damage could be prevented by proper methods of logging and production with little or no additional cost.

Exhaustive studies of insect investigation and control were continued in the Sequoia and Yosemite National Parks. Much new information has been gained, and the methods of gathering and compiling field data have been standardized.

A special study was completed on the interrelation of forest fires and insects on an area of about 8,000 acres in southern Oregon. This area had been under observation since 1914, and the fire had burned over about 800 acres in 1918. The records show that previous to the fire the insects had killed 485,000 board feet of timber. The fire killed 170,000 feet, and subsequently the slightly fire-injured as well as the uninjured trees in the burned area were killed by beetles, which were attracted from the surrounding areas. It was noticed that the infestation in the burned area increased more than 1,000 per cent, but it was found that the infestation in the surrounding areas decreased. It was also found that the broods of the beetles in the fire-scorched trees failed to develop to much beyond the original number that attacked the trees. So the fire did not contribute to an increase of the beetles in the general area or to the starting or extension of an epidemic of beetles. This result is of extreme interest and hardly to be expected.

The most careful study ever made of the history of an epidemic infestation by tree-killing beetles was completed and a report submitted during the year. In the Rogue River area in about 48,000 acres near Ashland, Oreg., the western pine beetle in 1914 caused the death of 346,000 board feet of pine timber. In 1915, 1,615,000 board feet were killed; 1,383,000 feet in 1916; and 608,000 in 1917. A count of the young and matured stages of the beetles that developed in an average foot of bark, and also of the number of exit holes through which the beetles emerged to attack other trees, showed that there was a notable decrease in numbers during the development of the broods each year in the infested trees on account of the increase of natural enemies and other disturbing factors. This helps explain why these beetle epidemics rise and fall within a limited period of years, and it explains how the western forests of yellow pine are naturally protected from total destruction. These facts are especially significant in connection with the application of the percentage principle of control, as by aiding the natural forces which work against the abnormal increase and spread of the beetles complete control may be gained. The history of this epidemic shows the importance of prompt recognition and prompt treatment of a threat-

ened outbreak in order to prevent the great loss of timber which would occur before natural control became operative.

Another special study was made of the number of all stages of the western pine beetle in 330 square feet of infested bark selected from 67 trees, which represented an average infestation within an area of approximately 36 square miles. It was shown that there is a large percentage of mortality between the young and matured stages in the developing broods, but that normally an average of about 150 beetles to the square foot of bark developed to the adult, or reproductive, stage; which would be 50,000 beetles to the average infested tree, or, say, 39,000 beetles to 1,000 board feet of timber. Since it requires an average of about 10 beetles to the square foot to attack and kill a vigorous, healthy tree, it will be seen that all the pine timber of the western forests would soon be destroyed were it not for natural and artificial control.

Experiments to determine the time of year to cut and the methods of handling mesquite for fuel, posts, etc., to avoid destruction by wood-boring insects, have been nearly completed, and the results show that serious loss in the Southwest can be prevented by cutting the trees in the late fall and early winter and piling the wood in loose piles until it is thoroughly dry. Damage to posts can be prevented by cutting them at any time and laying them on the ground where they will receive the full force of the sun, turning them occasionally so that the young stages of the borers will be killed by the heat.

Studies of damage to lead telephone cables in California by a wood-boring beetle have been continued, and the results so far show that the beetle is able to penetrate alloyed substances that are considerably harder than lead. The problem is still unsolved, and it will be difficult to find a practical means of controlling this pest, which is able to put hundreds of telephones out of commission by boring holes in the cables, through which the water enters, rendering the wire connections useless until the place is found and repaired.

EASTERN WORK.

Continued experiments with chemical substances applied to finished and crude forest products show that very few of the many substances that have been tried are effective, and, with crude products, none of them are so economical as simple and inexpensive management in logging and manufacture which will render the conditions of the bark and the wood unfavorable to attack.

Continued studies of termite, or white ant, damage to the woodwork of buildings has led to the discovery that one of the most destructive species can not live if deprived of moisture in ground or foundation timbers; thus it is possible to prevent serious damage.

Investigations of shade-tree insects have continued, and there has been much correspondence about insects of this class.

The recent appearance of the so-called seventeen-year locust, or periodical cicada, has given an opportunity for detailed study of certain points, and motion pictures have been made.

STUDIES OF THE BIOCLIMATIC LAW.

A law of latitude, longitude, and altitude as a guide to practice in fighting insects, and of value in the practice of agriculture, was first

worked out by Dr. Hopkins, the chief of this section, in relation to forest and other injurious insects. It has proved, however, of such wide application that he has worked upon its various aspects with much assiduity. Extensive studies of the advance of the spring season were carried on over a large portion of the United States, and over 19,000 records of periodical events in plants and insects were made in the East. The most important result of this special study of the advance of spring is in the almost complete verification of evidence in support of the law that has been formulated from a preceding study of 40,000 records of reported dates of wheat harvest and of records of altitude limits of life zones. Applications of this law appear to be of great value in the study of all problems relating to periodical farm practice, the warfare against insects among others.

TROPICAL AND SUBTROPICAL FRUIT INSECT INVESTIGATIONS.

This branch of the bureau's investigations is under the charge of the assistant chief of the Bureau, Mr. C. L. Marlatt,

Investigations of insects affecting citrus fruits in California.—A considerable portion of the time of the investigators assigned to this project has been devoted to extension work in connection with the efforts to stimulate production as a war measure. The research work of this station has been continued with respect to the investigation of the availability of liquid hydrocyanic acid for the fumigation of citrus trees and the control of citrus mealybugs and the Argentine ant. For the purpose of experimentation with the liquid hydrocyanic acid, a 600-acre citrus ranch at Orange was placed at the disposal of the agents of this department, and very careful records have been kept on the subject of dosage, exposure, and effect of meteorological and soil conditions, and also of previous insecticidal treatments. Paralleling these orchard experiments, certain necessary physical and chemical examinations have been made of the liquid cyanid, involving the examination and analysis of over a hundred different samples to determine variation in the chemical composition and the causes of such variation, involving both methods of production and impurities. This investigation has resulted in the determination of proper dosage tables for effective use against the different scale insects infesting citrus trees under the different conditions outlined—tables which have been published and are now available and are being generally followed in orchard work in southern California.

The control of the Argentine ant, which has rapidly spread during the last few years in the citrus districts in California with the resultant large increase of damage by mealybugs, which it harbors and distributes, has been continued and a more efficient ant poison has been developed especially in its application to the dryer conditions of California. Demonstrations with this poison in the control of ants and the attendant mealybugs have been made at the various places in the principal citrus-producing counties of California. A method of control of the citrophilus mealybug, which has recently become a very serious pest in limited regions of the citrus belt of California, by banding and the use of ant poisons, has been developed which has resulted in one of the most notable successes in

insect control done in the State. This method of control has practically eliminated this mealybug from upward of 500 acres near Upland, Calif., and, in fact, over most of the district infested by this insect, and for the first time in years the owners of these orchards are able to sell their fruit in prime condition at the highest market price. This method of control will be rapidly extended over the entire infested district.

In connection with the investigation of the two principal mealybug enemies of citrus plants in southern California, the parasitic and predatory enemies of these insects have been further investigated as also the symbiotic relations of these insects with the Argentine ant.

The department has cooperated with the California authorities in the determination of the best methods of exterminating the European snail (*Helix pisana*) which has become established in a small canyon or district near San Diego. As a result of this investigation and of various conferences the method of control now being carried out by the State is the burning over of the district with torches fed with oil under pressure totally to destroy the vegetation. This snail was possibly introduced by some foreigner familiar with its food value in Europe, without thought as to its tremendous possibility for harm to cultivated crops.

Citrus fruit insects in Florida.—The work under this project during the year has been largely limited to demonstrational work in the aid of increased production. Spraying demonstrations have been conducted widely throughout the State. A revised schedule for fumigation and treatment of trees to prevent insect injury has been worked out for the grapefruit, and a Farmers' Bulletin (No. 1011) has been issued entitled "The Woolly White Fly in Florida Citrus Groves." Some special lines of investigation have had to do with the stabilizing of insecticides especially where the only water available is obtained from deep wells containing a large percentage of mineral elements which more or less affect the stability of certain emulsions and other insecticides. The work in Florida has had particular relation to the citrus white fly, the rust mite, and the common Florida scale insects. The work in the control of citrus pests in Florida has shown the greater availability of liquid sprays over the fumigation methods commonly followed on the Pacific coast. During the last two years, however, considerable demonstration work has been done with fumigation in Florida by a private concern, the results of which have been carefully examined by the expert of this department as a protection to citrus growers and to determine that any claims made are fully justified.

Investigations of insects affecting mango, guava, avocado, and other subtropical fruits.—The mango and avocado and other fruits mentioned under this heading are being commercially developed on a considerable scale in southern Florida. A station has been established at Miami in cooperation with the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry of this department to investigate the peculiar insect enemies of these fruits. Due to the proximity and commercial connections of southern Florida with Bermuda, the West Indian Islands, and Central America, this region is especially open to invasion by important fruit pests, and several of these have already gained entrance. One feature of the project,

therefore, is to cooperate with the Federal Horticultural Board in safeguarding against further introductions of such insects from the sources named. The work of the last year under this station has had particular relation to several important insect enemies of the avocado. Already effective means of control of the principal avocado insects have been devised, notably with respect to leaf-infesting mites, to species of thrips, and several scale insects. Work has also been done with respect to insect enemies of the mango and the papaya.

Studies of greenhouse insects.—Under this project, life-history studies and methods of controlling the chrysanthemum midge, a very important injurious insect of this plant in eastern greenhouses, have been completed and presented for publication. A bulletin (Department Bulletin 778) has also been published during the year giving the life history and methods of controlling the rose midge. Work has also been done with respect to the effective utilization of various insecticides and in the general problem of fumigating plant houses.

Mediterranean fruit fly and melon fly.—This work is a continuing one, and has been carried on at the bureau's laboratory in Honolulu. The research features of the work have consisted in further studies of control by the agency of parasites and natural enemies. The principal work, however, has remained as heretofore in the inspection and certification of bananas, pineapples, taro, and coconuts for shipment from Hawaii to the mainland of the United States.

Geographical distribution of fruit flies.—The work under this project has for its special object the surveys of districts contiguous to the United States, from which the importation of fruit and plants may be the means of introduction of fruit flies and other enemies of important fruit crops. During the past fiscal year the field work under this project has involved explorations of the Panama Canal Zone, British Guiana, and the West Indian Islands of Barbados, Trinidad, Tobago, and Grenada, continuing the work which was done the previous year in Cuba, Jamaica, Dominican Republic, and the Virgin Islands. In the course of this work a great many insects have been collected and studied of known or potential economic importance and in addition a very considerable miscellaneous collection of insects has been made. The investigations were conducted in plant gardens maintained by the local departments of agriculture of the different islands and such general surveys as were possible within the time limits. Particular attention has been paid throughout the work to fruit flies, scale insects, and such other pests as are particularly likely to be carried from country to country by traffic in fruits and plants. A good portion of the time of the expert engaged in this work is necessarily devoted to the identification of the material collected and the working up of results.

Investigation of fruit flies and other tropical and subtropical fruit insects in the Canal Zone, Panama.—This is a new project which has been established in cooperation with the authorities governing the Panama Canal Zone and the Federal Horticultural Board to study the important insects infesting tropical and subtropical fruits, cultures of which are being developed under the encouragement of the Government authorities in the zone. The importance of this investigation is due to the fact that the several important

fruit flies and other tropical and subtropical fruit insects are now established in the zone, and to the further fact that the zone is more or less of a world's crossroads, i. e., a place where insect pests from remote places may be carried through the agency of commerce and easily gain lodgment, later, perhaps, to effect entry into the mainland cultures, tropical and subtropical, of the United States. This work, now in progress for one year, has developed useful information. Much work has been done in connection with the so-called black fly of citrus and other plants, which has become established in the Canal Zone and in the West Indies, and which a very determined effort is being made to exclude from the southern United States. A considerable number of other important injurious insects have already been discovered and have been the subject of studies. Among these are no less than four different kinds of fruit flies. There have been found in the Canal Zone also a number of insects which very injuriously affect commercial woods and wood structures. Termites are very important subtropical insects found in the Canal Zone. Several of these are abundant in the State of Panama and several have been found in the Canal Zone, some of which are very destructive to garden crops. The entrance of some of these into the United States would be followed by great injuries. The number of subjects which have been investigated at this station is already enormous, and a very convincing showing has been made of the need of keeping constantly in touch with the plant cultures and insect enemies in this district as a means of benefiting local production, but particularly as furnishing information on which any necessary protective action in the interests of the United States may be taken.

WORK ON THE GIPSY MOTH AND BROWN-TAIL MOTH.

This work has been continued under the supervision of Mr. A. F. Burgess, with headquarters at Melrose Highlands, Mass.

For the first time since the bureau began work to prevent the spread of these insects, it is possible to report a substantial decrease in the infested territory. This amounts to 1,824 square miles previously infested with the gipsy moth and 5,385 square miles by the brown-tail moth. Twenty-eight towns in New Hampshire, 6 in Vermont, 8 in Massachusetts, and 10 in Connecticut, 52 towns in all, were found to be free from gipsy moth infestation and were eliminated from the quarantine area this year. There is now under quarantine on account of the infestation by the gipsy moth 20,747 square miles in New England. Isolated colonies of the gipsy moth, which were found in previous years in New York, Ohio, New Jersey, and the western part of Massachusetts, have again been carefully examined but no infestation found. There seems to be no reasonable doubt that the insect has been exterminated in these colonies.

The decrease in area infested with the brown-tail moth includes 34 towns in Maine, 58 in New Hampshire, 6 in Vermont, 37 in Massachusetts, and 10 in Connecticut, a total of 145, embracing an area of 5,385 square miles which was released from quarantine this year. There are now quarantined on account of this insect 28,752 square miles.

Field control work.—The field work has been carried along on the same general lines as in previous years. As the scouting of the border area failed to reveal infestations in many towns, it was possible to devote more time and effort to the control of bad colonies located on exposed places in towns inside the border. Work of this character is exceedingly important, as it tends to reduce the opportunity for small caterpillars to be spread by the wind and helps to prevent new infestations from becoming established outside the border and in the area which has been cleaned. Scouting was carried on in 130 towns, and in a number of these towns the work was checked up by special scouts, known as trailers, to determine whether egg clusters were being missed. This method is constantly employed in order to keep the work on an efficient basis.

In the fall of 1918 several tons of gipsy moth banding material was prepared at the field storehouse at Franklin, N. H. About 4 tons of this material was applied to the trees early in the spring, and excellent results were secured. During the winter five of the horse-drawn spraying machines were converted into motor-propelled outfits and there were available 12 motor-truck sprayers and 7 horse-drawn machines, with the necessary hose, nozzles, and other accessories. These machines were distributed along the infested border and work was taken up as soon as the foliage was large enough to be sprayed. For the first time since the work began, dry arsenate of lead was used instead of paste. The results were satisfactory; and more of this material will be used in the future if the price is as favorable as is that of the paste form.

Spraying was carried on in 36 towns as follows: New Hampshire, 25; Massachusetts, 3; Rhode Island, 4; Connecticut, 4; 3,280 acres of infested woodland was sprayed; also 6,800 fruit and shade trees. This work in the border territory was greatly facilitated by the spraying carried on by the State entomologist in Connecticut. The work was arranged so that one motor truck furnished by the State and one horse-drawn sprayer treated the infestations in a number of towns.

Experimental work.—In the fall of 1918 many sample collections were made to determine whether the severe winter had adversely affected the imported egg parasites, namely, *Schedius kuvanae* and *Anastatus bifasciatus*. The results indicated that Schedius had not been able to survive the winter in New Hampshire, except possibly in a few of the more favorable locations. This species was also very scarce in Massachusetts, except in the southern part of the State. Anastatus came through the winter in better condition, although its numbers were decreased somewhat. Owing to these conditions, plans were immediately made to colonize large numbers of both species during the fall and winter.

Five million specimens of Schedius were colonized in Massachusetts and New Hampshire in the fall of 1918, and 10,000,000 specimens of Anastatus were colonized in the spring of 1919; 2,016 colonies of the latter were liberated in Massachusetts, 6,286 in New Hampshire, 1,659 in Maine, 127 in Rhode Island, and 144 in Connecticut. The completion of this work was made possible by assistance secured from the officials in the different States.

Compsilura concinnata was slightly less abundant than has been the case for the past three years, but in some localities it was present in satisfactory numbers. The species is widely distributed, having been recovered during the present summer in the Annapolis Valley in Nova Scotia. It attacks many species of native caterpillars and is particularly valuable on that account. This habit also makes it possible for the species to maintain itself in territory which is not infested with the gipsy moth or the brown-tail moth.

Blepharipa scutellata has been found more widely distributed this year than heretofore, and in some locations a fair degree of parasitism has been recorded. In the territory as a whole it probably has not reached its maximum numbers. Field collections indicate that *Apanteles melanoscelis* is not quite as abundant as was the case last year. This is evidently due to the work of secondary parasites, as many of these have been reared from cocoons of the second generation of Apanteles. This species probably has not increased to maximum numbers.

Calosoma sycophanta was not as abundant this year as heretofore, and this was particularly true in some localities where it had been very numerous during the past two or three years. The wilt disease was not nearly as common as usual and this condition seems to be rather universal throughout the territory infested with the gipsy moth. Further studies are being conducted relative to the Japanese disease of the gipsy moth (*Streptococcus disparis*), and more colonies are being liberated in order that a thorough study of its value may be made in the field.

While the area infested with the brown-tail moth was considerably reduced during the past year, the insect seems to be increasing slightly in the eastern part of the territory. Collections of brown-tail moth webs from 100 towns were made during the winter by State and town authorities and forwarded to the laboratory. Dissections of about 10,000 larvæ taken from these webs indicate that *Apanteles lacteicolor* was present in small numbers, while *Meteorus versicolor* was much less abundant. The most common parasite found in these collections was *Zygobothria nidicola*; 20 per cent of the caterpillars in the entire lot were parasitized by this insect.

Only a few localities have been found this summer where brown-tail moth caterpillars are at all abundant, and the fungus disease (*Empusa aulicae*) has not been reported.

Work on a more effective material for banding trees is under way and preliminary tests to determine the relative value of dusting with arsenate of lead versus spraying have been started.

The study of the gipsy moth problem on cranberry bogs has been nearly completed and much valuable information secured.

The work of securing data on the mortality of different species of trees that have been defoliated is being continued and silvicultural investigations are being carried on principally on the sample plots established some years ago.

Quarantine work.—The quarantine of the areas infested with the gipsy moth and the brown-tail moth made necessary during the fiscal year the inspection of 29,394 shipments. These consisted of forest, nursery, and quarry products; also Christmas trees and greens.

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In addition to the inspections made, 623 permits were issued to allow the shipment of material of this sort which originated outside the quarantined areas but was offered for shipment inside the areas.

PRESENT CONDITION OF THE AREAS INFESTED WITH THE GIPSY MOTH AND THE BROWN-TAIL MOTH.—The winter of 1917–18 was the most severe that has been experienced in New England for many years. Not only was the temperature abnormally low, but the snowfall was exceedingly heavy, except along the coast. These conditions were partly responsible for the failure of many gipsy moth eggs to hatch in the spring.

In the summer of 1918 serious defoliation by the gipsy moth existed in the Cape Cod region in Massachusetts, but small defoliated areas could be found in many other sections. Advantage was taken of this condition in planning the field work in the summer and fall of 1918, and, by taking advantage of the reduction in infestation in many localities, it was possible to clear many colonies.

The winter of 1918–19 was exceedingly mild and gipsy moth eggs survived and a very large proportion hatched.

Some of the parasites, particularly Schedius, which destroys gipsy moth eggs in the fall, were not nearly as numerous this year as heretofore, and the other introduced parasites do not appear to have fully recovered from the setback received during the previous winter. The wilt disease was also less abundant and effective this year than usual. As a result of these conditions heavy feeding by the gipsy moth has appeared over the greater part of the infested area in eastern Massachusetts and New Hampshire.

The present indications are that stripping will be more severe next summer, and if weather conditions are favorable for the spread of the small caterpillars by the wind next spring it will not be surprising if some of the recently cleared border towns become reinfested. The gipsy-moth problem is therefore more difficult than usual and the most strenuous measures will be necessary in order to hold the insect within the territory now infested until the parasites and diseases have become more numerous and effective in the worst infested regions.

The brown-tail moth appears to be on the increase in the eastern part of the territory, although special efforts were made by the State officials to clean up isolated infestations in the spring of 1919. Unless all colonies of this insect are thoroughly treated it is likely to increase its range.

EXTENSION AND DEMONSTRATION WORK.

This work was instituted under the provisions of the first food-production act and continued during the fiscal year under funds made available to this bureau under the second food-production act. Mr. J. A. Hyslop has been in charge of this work from its institution to its final termination on June 30, when the war activities of the department were closed.

During the past fiscal year 4 additional States entered into project agreements with the Bureau of Entomology, making a total of 37 States cooperating with the bureau in teaching entomology in the

field. An average of 75 specialists from the bureau has been maintained, 109 men having been employed during the year. The apparent increase in the personnel, in spite of its prospective termination at the end of the fiscal year, is due to the large force engaged to spread information and to do survey work in the attempted control of the imported European corn borer and in the extension of the oriental peach moth activities of the bureau.

The policy during the year has been gradually to reduce the personnel and to place this work on a permanent basis in the State extension service. A number of the agents engaged in extension work were transferred to fill vacancies in the research branches of the bureau's activities.

Owing to the success of permanently connecting the field agents with the extension staff of a State, instead of carrying on the work from a regional standpoint as was done last year, the work has been placed in a much better position to be finally absorbed by the State than would have been possible otherwise.

Most of the beekeeping work has been placed upon a definite cooperative basis and financed jointly by the State and the bureau. The balance of the work, however, has been entirely financed by the Federal Government.

The work on control of insects affecting domestic animals was a notable exception to this plan. As there were very few men fitted to do extension work along this line, it was found necessary to have the bureau's agents cover several States during the working season.

During the year 69,000 people were reached. This decrease from last year was largely due to the rapid decrease in the personnel at that time of the year when the most effective extension work can be carried on.

The bureau's representative in this work is cooperating with the States Relations Service by inspecting and criticizing all projects submitted for Smith-Lever fund work along entomological lines.

Another activity of this office has been the work in connection with the bureau's entomological exhibits. This year an exhibit of photographic bromide enlargements illustrating the most important insect and control methods, models of insect-catching devices, spray machines, dusting machines, and other entomological appliances, and cabinets illustrating the more important insecticides were sent to France to be used in connection with the educational work being carried on by the Young Men's Christian Association among the American soldiers.

Competent and instructive exhibits have been prepared, to be shown at the State fairs this year.

SOUTHERN FIELD CROP INSECT INVESTIGATIONS.

The work of this class has been carried on, as before, under the direction of Dr. W. D. Hunter.

Poisoning the cotton-boll weevil.—In last year's report it was shown that one of the most striking achievements of the bureau which culminated during the year was the determination of the great value of powdered lead arsenate or calcium arsenate against the cotton-boll weevil. Large-scale experiments have been continued since that report. The methods and details of procedure of keeping

the boll weevil in check by this method have been improved and thoroughly tested on a large scale. Cotton planters all over the weevil-infested portion of the cotton belt are taking up this method, and hundreds of individual inquiries in regard to it have been answered. The bureau is certain, however, that the exact methods which have been successful under conditions that exist in the Mississippi Delta will not be perfectly applicable to all portions of the cotton belt. Therefore, circulars have been issued regarding the general application and making it plain to planters that methods should be varied according to conditions. The weevil has been more numerous during the summer of 1919 than it was during the previous summer, and planters have therefore been more than ever desirous of trying this remedy. The bureau, therefore, has been especially anxious to guard them from mistakes.

An enlargement of this investigation seems necessary to bring about the best results. Experimental farms should be established in a dozen or more cotton-growing regions, and the very best method for each region must be worked out before planters can apply the remedy with confidence. The commercial results that have been reached already, however, in the delta region assure ultimate results of probably equal value in the other parts of the cotton belt after these comparative studies shall have been made.

Other cotton insects.—At the laboratory at Madison, Fla., a study of the Hemiptera attacking cotton east of the Mississippi River has been completed. At this station also a thorough study has been made of the varieties of sea-island cotton with especial reference to earliness of growth under boll-weevil conditions. Thirty-two varieties have been tested in this work. The importance of early fruiting of sea-island cotton under weevil conditions can not be overestimated. Careful studies at this point have also been made on the relation of the immature stages of the weevil to temperatures. The dry period in Florida, usually commencing about the 20th of May and extending to the 20th of June, seems to retard the weevil to such an extent that the problem of growing upland cotton under weevil conditions is very encouraging.

Insects affecting sugar cane.—The best hope for control of the moth borer of sugar cane now seems to be the importation and establishment of parasites which exist in Cuba. Experts were sent to Cuba in the beginning of the fiscal year and again in April, 1919. Parasites have been imported, and every effort is being made to propagate them in the Louisiana cane fields.

Tobacco insects.—In Florida, promising control of the tobacco flea-beetle has been obtained with certain insecticides—an important result, as in 1918 one grower claimed a loss from this insect of $650 per acre. Dusting methods in the shade-grown tobacco region have been revolutionized by the introduction of power machines which are capable of dusting from 10 to 20 acres per day more than can be done with hand dusters. For the tobacco thrips it has been found that nicotine sulphate, 14 ounces, and soap, 3 pounds, to 50 gallons of water, gives satisfactory control if applied properly once a week during the emergence period. A very important point is the time of application. Much valuable work has been done on other tobacco insects.

Rice insects.—A Farmers' Bulletin treating of the principal insect enemies of the rice crop in the United States has been prepared for publication.

INSECTS AFFECTING THE HEALTH OF MAN AND ANIMALS.

In cooperation with the National Research Council and the Surgeon General's Office of the War Department, studies on the body louse were actively pursued during the year. This work resulted in the accumulation of much practical information concerning the value of the laundry processes, the dry-cleaning processes, and other means of control. A large number of chemical methods of treatment were also studied, and additional observation on the bionomics of lice was made. Many proprietary louse remedies were carefully tested, in cooperation with the Insecticide and Fungicide Board, thus protecting the Government against expenditures for worthless remedies.

An expert of the bureau has been assigned to work, in cooperation with the Public Health Service, on the problem of the species and habits of flies breeding in human excreta, especially in the open privies in rural communities of hookworm regions. The headquarters of this work are at Wilmington, N. C.

Several of the experts of the bureau were assigned to sanitary work in the Army, especially with relation to the insects that carry disease.

The work on insects affecting domestic animals has been considerably enlarged. Investigations of the biology, distribution, and methods of control of the ox warble were especially taken up, and important facts were gained in regard to biology. The work upon the screw worm was continued, as well as investigations of the horse-flies in eastern California and Nevada. Life histories of three of the more important species have been fairly well worked out. The lice of domestic animals have been studied from the remedial point of view, and methods of applying sodium fluorid to destroy chicken lice and pigeon lice have been perfected. Some supervision of certain packing establishments has been carried on in the effort to reduce the number of flies. This has been a continuation of previous work and is of much importance.

BEE CULTURE INVESTIGATIONS.

This work has continued under the supervision of Dr. E. F. Phillips. It has been chiefly a continuation of the campaign for increasing the honey crop, which was begun as a war measure. The educational activities then begun have been so eagerly received that they can not be discontinued, and it is still important that the enormous loss of ungathered nectar shall be reduced. During the year the apiary and laboratory were moved to a building in Somerset, Md.

Demonstrations in bee culture.—In addition to funds available under the regular appropriation, $15,000, available from the food-production act, was used for demonstrations. The work was conducted as one project. As qualified men were found the number of agents was increased until there were in the field 16 men, working in cooperation with the several extension divisions of the 20 States to which they were assigned. Because of the great difficulty of finding competent men, it was possible to maintain an average force of only 12.

The work of these men was an effort to instruct beekeepers in better methods of production and care of their bees, so that the honey crop of the country might be increased. It will be desirable for many years to keep on increasing the production of honey, in order to conserve this natural resource which is now so generally wasted. There was also a great demand for honey for export to the allied countries, and this demand has continued since the cessation of hostilities.

During the fiscal year the field men, assisted from time to time by the regular office force, held over 1,000 meetings, attended by 25,000 beekeepers, and in addition they have visited over 2,500 apiaries and have given personal instruction to the owners regarding their beekeeping practices. The work of organizing the beekeepers into associations has been continued, and in several States these county organizations are being federated with the State beekeepers' organizations. There are now over 300 such county associations of beekeepers. During the year arrangements were made so that every man of the field force is assigned to a single State in cooperation with the extension divisions, both cooperating organizations paying part of the expense.

The meetings held by the field men must be limited in the topics discussed, and it is impossible to cover many important lines of work for lack of time. To overcome this difficulty a trial was made in the holding of extension short courses of a week's duration. The first of these schools was held in California during the year, and these were so successful, in spite of the severe influenza epidemic, that the same plan was later put in operation in New York, Indiana, Iowa, and Minnesota. The average attendance at these schools was about 100 beekeepers, who came for intensive instruction for a period of a week, and the work with these men during these schools leads to a strong belief that more good was done than could have been accomplished in the same time with shorter meetings even with a larger number in attendance. These schools are planned for commercial beekeepers. The instruction was on fundamental problems of the beekeepers, no attention being given to the mere simple mechanical operations, but emphasis was placed on the reasons for various practices as based on the behavior of the bees. In every State where the work was given the beekeepers and extension officials have asked that similar schools be held in the future, and other States have asked for schools.

A bulletin on commercial comb-honey production (Farmers' Bulletin 1039) was issued during the year. It is a revision of Farmers' Bulletin 503. A bulletin on swarm control is in process of preparation, and one on extracted honey production. When these bulletins are issued it is planned to publish a bulletin on beginning beekeeping, and then to discontinue the present general bulletin on beekeeping (Farmers' Bulletin 447) and to replace it with one which will serve to tie together the various technical bulletins on special topics.

Wintering of bees.—Little work has been done during the year on the investigational phases of this problem, because the field men have been necessarily occupied with purely practical work and the office force with answering requests for information sent in by beekeepers, but observations have been continued which fully substantiate the results of the more detailed work. During the year two

bulletins of a practical nature were published—Farmers' Bulletin 1012, on the care of bees when wintered outdoors, and Farmers' Bulletin 1014, on wintering bees in cellars. These bulletins give explicit directions for the care of bees during the winter season and contain recommendations applicable to the entire country. It is gratifying to report that beekeepers throughout the country are paying more attention to the careful wintering of their bees since the bureau took up this subject for investigation.

Diseases of bees.—During the year a paper (Department Bulletin 780) was published on Nosema disease, a malady of adult bees which may at times cause some loss. A bulletin (Farmers' Bulletin 975) was issued on the preventive and remedial measures to be employed against European foulbrood, and in this bulletin for the first time detailed attention is given to the factors which may successfully be used by the beekeeper to prevent the inroads of this disease. Papers on the etiology of American foulbrood and European foulbrood were also prepared, and a paper on the behavior of bees in the cleaning out of European foulbrood, a phase of investigation which had previously been neglected, but one which now promises to yield most important results from the standpoint of control of the disease. An investigation was made of the peculiar manifestations of European foulbrood in California, where, because of the climatic conditions and the character and time of the honey flow, and perhaps especially because of the methods of beekeeping employed, the disease is unusually destructive and shows characteristics not often encountered elsewhere. During the year 563 samples were received from apiary inspectors and from beekeepers for diagnosis.

EFFECT OF THE WAR ON BEEKEEPING.

In the last annual report attention was called to the effects that the war had on the beekeeping industry. The increased demand for honey for export has continued ever since the cessation of hostilities and there is reason to expect that this market will continue to be an important factor in American beekeeping. During the period of severe sugar shortage, the home consumption of honey was greatly increased, but beekeepers were worried for fear that when sugar became plentiful this demand would cease. If beekeepers are able to produce enough honey to meet this increased and increasing demand this enlarged home consumption will continue. The local sales of honey, near the points of production, increased more rapidly than sales in the larger markets, but this can readily be remedied by the further development of the larger bottling trade in honey for which there is demand.

After the winter loss in the white clover region during the winter 1917–18, the beekeepers of this region found themselves short of bees in the spring of 1918, just at a time when there was the greatest opportunity to build up their business. This produced a great demand for bees in combless packages from the Southern States and resulted in the building up of a large business of this character, which will continue and will be an important factor in beekeeping in the future. The supply of bees from the South in 1918 probably did not fully replace the winter loss during the summer of 1918, but because of the increase made by beekeepers there are probably

more bees in the important clover region than ever before. The demand for queenbees to be furnished by professional queen breeders was so great during the spring of 1919 that practically all of them had more orders by May 1 than they could fill during the entire summer. In the West, where the loss of bees was not unusual, there has been even a greater increase in the holdings of the larger beekeepers, resulting in a greater difference between the commercial holdings and the bees in the hands of amateur beekeepers. The tendency to collect the bees of the country in the hands of commercial beekeepers is a most wholesome sign for the proper development of the beekeeping industry for the future, and the war's net result on beekeeping will be an increase in the commercial aspect of the business. The increase of commercial beekeeping has greatly increased the demand for assistance to beekeepers and has made them eager to accept the extension activities of the office. The correspondence of the office is now twice what it was before the entrance of the United States into the war. The demand for beekeepers' supplies and for literature on beekeeping has been greater than ever before in the history of beekeeping in the country.

In explanation of the desirability of making the beekeeping industry one which is in the hands of professional beekeepers rather than to urge the keeping of bees on every farm, it may be stated that the prevalence of the two destructive brood diseases throughout the country, and especially the necessity of careful study of beekeeping problems in order to obtain the maximum crop, make it almost impossible for the person having only a few colonies to give the care to the bees which will result in good beekeeping. Only the man who makes this his chief work may expect to get the returns which are obtained from colonies properly cared for.

GENERAL SUMMARY OF THE WAR ACTIVITIES OF THE BUREAU.

(1) A very perfect system of reporting insect outbreaks was organized, the result of which was a close knowledge of the exact conditions almost from day to day of insect-pest increase over the whole United States. These conditions were made known to all of the economic entomologists of the country through circular letters, and by cooperation based upon this intimate knowledge crop pests were held in check and food production greatly helped.

(2) By conferences with the chemists and the insecticide manufacturers the problem of the reduced quantity of arsenic (on account of its use in munitions) was met, and by conservative use and better distribution the supply was made to cover the needs of the farmers, fruit growers, gardeners, and others.

(3) The bureau assisted the Quartermaster General's Department of the Army by inspecting the enormous quantities of grain and other material intended for shipment to Europe and gave advice as to fumigation and other treatment when such stored products were found to be infested with insects. It also inspected warehouses and mills in the same way in many parts of the country.

(4) Advice was given to representatives of the War and Navy Departments and the Shipping Board relative to insect damage to lumber and stored wooden implements.

(5) By the efforts of the beekeeping section of the bureau the beekeepers of the country were aroused to the necessity of a great increase in honey, owing to the shortage of sugar. Specialists were sent out, held meetings, addressed more than 25,000 beekeepers, visited the apiaries, and gave personal instruction, with the result that the honey crop was greatly increased. Our exports of honey to allied countries increased at least ten times over those of any period previous to the war, and the domestic consumption of honey also greatly increased.

(6) In medical entomology the bureau maintained a thorough cooperation with the Office of the Surgeon General of the Army in the matter of experimental work on insect problems. All insect remedies reported to the Medical Department of the Army were referred to the bureau for opinion or for test. The most extensive work was done on the subject of the body louse, and branch laboratories were established for experimental tests. Experts of the bureau were in several cases engaged for special work in concentration camps against insects carrying disease, and at the close of the war one of these experts, who had early entered the Army as a reserve officer, had virtual charge of the great delousing plant at Camp Mills, through which troops returning from Europe were passed.

The foregoing six paragraphs include only the broadest outline of the work which, were it to be stated in more detail, would indicate that in very many directions the bureau's services were most important.

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